

**ABSTRACT**

An improved barrier stack for inhibiting diffusion of atoms or molecules, such as O<sub>2</sub> is disclosed. The barrier stack is particularly useful in capacitor over plug structures to prevent plug oxidation which can adversely impact the reliability of the structures. The barrier stack includes first and second barrier layers having mismatched grain boundaries. The barrier layers are selected from, for example, Ir, Ru, Pd, Rh, or alloys thereof. By providing mismatched grain boundaries, the interface of the layers block the diffusion path of oxygen. To further enhance the barrier properties, the first barrier layer is passivated with O<sub>2</sub> using, for example, a rapid thermal oxidation. The RTO forms a thin oxide layer on the surface of the first barrier layer. The oxide layer can advantageously promote mismatching of the grain boundaries of the first and second barrier layer.